1887

The Ore Knob copper process

Oscar Lachmund

THESIS

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Ore Knob Copper Process

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LACHMUND

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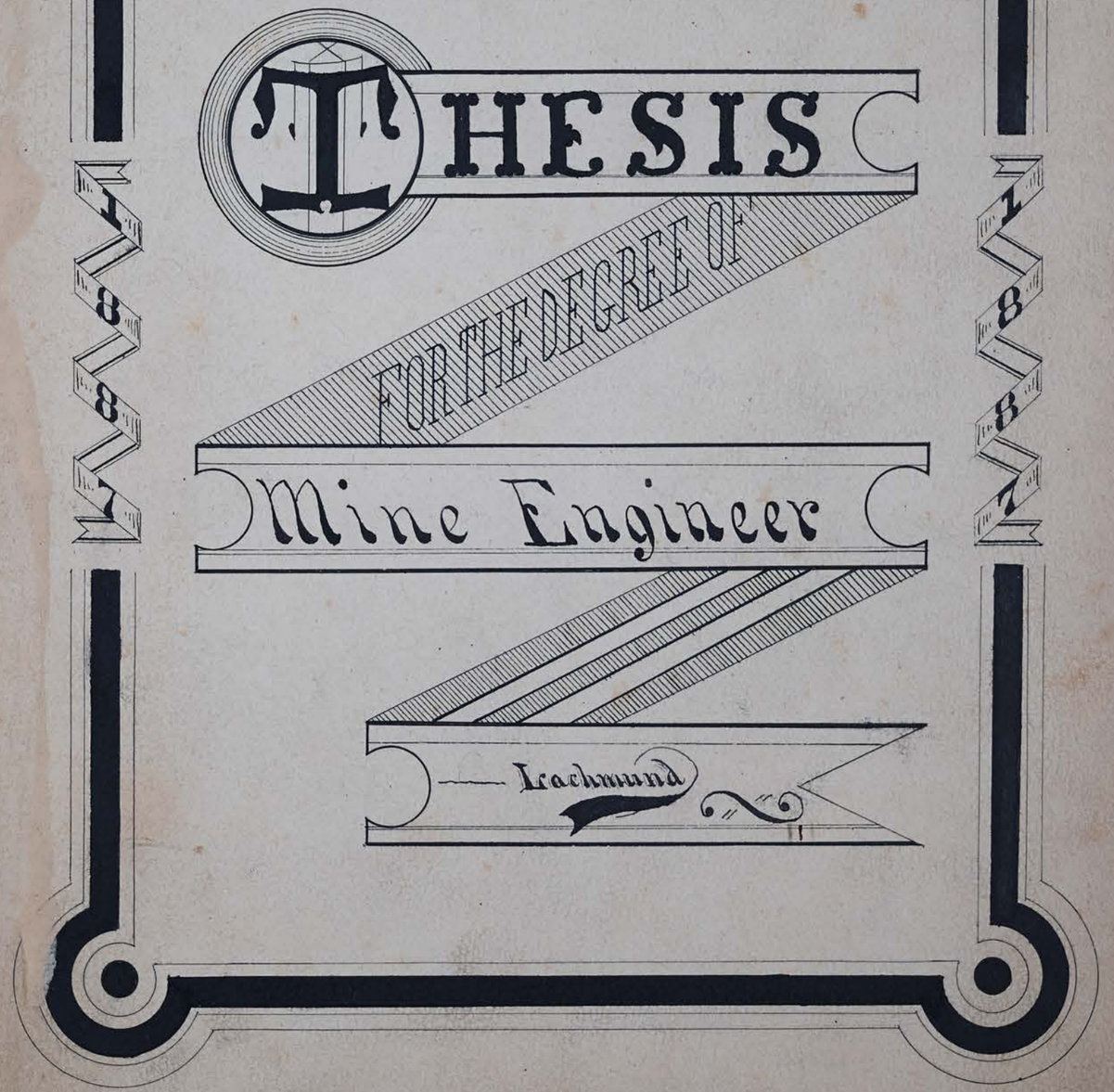

THESIS

FOR THE DEGREE OF

Mine Engineer

Lachmund

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Class of '87

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The works of the Ore Knob Copper Company are situated in the County of Ashe in the north-western part of the state of North Carolina, about ten miles from the Virginia line at an elevation of 4000 feet above the sea.

The works are 45 miles from the railroad, which makes the transportation very difficult. These unfavorable conditions make it necessary for the owners of the mine to smelt their ores and to send to market nothing except the metal, which alone will bear the cost of transportation. The mine was opened previous to 1860, but has only been worked successfully during the last 8 or 10 years.

The vein is a fissure-vein from 10 to 20 feet in thickness, and has been explored over a long distance by working and trial shafts. The method of mining employed is known as underhand stoping.

The rock is hard, but the ore is won without much difficulty. The method of extraction is by iron buckets. These hold from 1000-2000 lbs. each. They are placed on a truck which, when loaded is rolled to the shaft and the buckets are there hoisted. The ventilation of the mine is excellent, the foul air from a blast being removed in

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a very short time. The smelting works are situated only a few hundred feet from the mine. The ore is delivered into the dressing-house, where that containing copper is separated from the sterile materials, and discharged into a car running by gravity to the smelting works, where it is dumped into carts and carried to the piles to be roasted.

It has been found by experiment that an ore containing 3% of Copper just pays the expenses of mining and smelting.

The metallurgical works consist of six roasting sheds, ten shaft furnaces, one reverberatory furnace and four houses for storing the coal. The fuel used is wood for roasting and refining and charcoal for the shaft furnaces.

Pig Copper is obtained in four & ingot copper in 5 operations.

The process consists of:

1. Roasting the picked ore the dressed fines in piles
2. Fusion in a shaft furnace for mattes, called single mattes
3. Roasting the mattes in piles
4. Fusion in a shaft furnace for black ore pig copper & concentrated or double mattes
5. Treatment of the Salamanders
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I. Roasting the Ore

The roasting of the ore is effected in three sheds each 34 feet wide and 300, 280, and 240 ft. long respectively. They are capable of holding 42 piles; 16 in the first, 14 in the second & 12 in the third.

These piles at 1.7 x 20 feet & 8 ft. high in the middle and contain 100 tons of fresh ore & about 50 tons of partially roasted ore, making in all about 150 tons for each pile.

They are made right on the ground, putting down first about 10 to 12 inches of very fine ore. Over the fine ore 3 cords of good wood are placed in two rows beneath the whole piles; three rows are made on the outside so as to hold up the sides of the piles.

The ore which is broken to about the size of the fist, is piled over the wood.
The outside of the pile is covered with ore in pieces about the size of a hickory nut, and the fine unfinished ore is placed on the top and sides of the piles, then the very fine screenings over this on the top and sides. On the bottom at the sides the piles almost touch. As the ore con-

tains a very large amount of sulphur, but little fuel is required for the process.

The greatest part of the heat is due to the sulphur in the ore. The pile soon settles from the burning out of the wood, when the cracks are made tight with fine ore, leaving only just enough of them open at the bottom of the pile, to allow the heat to come from below up.

In driving off the sulphur, sufficient must be left to form the matte, but enough must be driven off to insure that as much of the iron as possible shall pass at once into the slag.

The pile is lighted at the four corners and it takes about 24 hrs. to get it well burning.

It takes about six weeks to burn a pile. When taken down it is about 3/5 roasted and the rest goes into a new pile.

The fine ore at the bottom is generally entirely agglomerated, so that it has to be broken with a pick or a sledge.

The piles are discharged before they become cold.

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The following are analyses of two samples of Roasted Ora:

	No 1,	No 2.
Copper	4.68	3.94
Iron	39.08	38.38
Sulphur	6.76	7.64
Alumina	1.79	2.68
Manganese	.40	.86
Lime	8.10	8.01
Magnesia		
Silicious Residue	15.20	17.52

The cost for roasting one ton of the ore is only 18 cents per day.

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II. Fusion for Mattes.

As soon as the roasted ore is taken from the piles, it is carried to the shaft furnaces.

The furnaces used for smelting ore & matte are the same in construction.

There are 8 ore furnaces, which, when all are running, produce about 40 tons of matte, or about 5 tons each in 24 hrs.

The furnaces are rectangular in section and have two tuyeres in the back 3 inches in diameter, with nozzles 2 1/4 inch in diameter.

The tuyeres converge so that lines drawn through their centres meet at 21 inches from the nozzle. The material of which the furnace is built, is partly soapstone and partly firebrick.

The whole of the furnace below the tuyeres is made of crushed quartz.

The furnace is 2 ft. 4 inch wide at the tuyeres and 3 ft 10 inch under the tymp. It is 8 ft high on the tuyere side and 9 ft 4 inch. on the breast side.

The tymp is made of a piece of soapstone 6 x 12 inches, which goes across the whole front of the furnace.

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The tymp is made of a piece of soapstone 6 x 12 inches, which goes across the whole front of the furnace.

The tuyere is 12 inches above the hearth, which inclines to the front so as to be 18 inches below the centre line of the tuyere.
The damstone does not exist in the ore furnace, but goes across the front of the pig copper furnace, which is in all other respects similar.
On the front of the furnace is a fore-hearth made of pieces of cast iron bolted together.
It is 5 ft. wide and 30 inches high next the furnace, and 28 inches and 2 ft. high on the front. In the middle of the front a spout is bolted on for the slag to flow over.

Next to each furnace and connected with it directly is a large dust-chamber, which is 4 x 8 x 16 ft. on the inside.

The total cost of one furnace by actual estimation is $706.88.

The charging-bed is made on a level with the throat with 6 loads of roasted ore containing about 1500 lbs. each, which is spread out over the charging floor directly behind the throat of the furnace. The charging floor is 22 ft. wide and 150 ft. long. Over the ore one load of cleanings from the front of the furnace is then spread. One load of tips of the slag-pots containing foul slag, weighing about 1500 lbs. & 1 load or 1200 lbs. of flue-dust mixed with clay are then put on. The slag runs continually

over the spout on the fore-hearth into a slag-
pot placed in front of the furnace.
The fore-hearth is always cleaned out just
before tapping. It is generally cleaned twice
in twelve hours.
Immediately after the last cleaning it is tapped.
The tapping is made twice every 24 hours,
and 90 slag-pots are filled every shift
of 12 hrs. About one-half the slag used in
the furnace is rich slag, which is added
for a flux. The matte runs into a casting
pit lined with a sleep made of 1 part
burned clay and 2 parts fine charcoal.
It is about 2 ft. deep and 4 ft in diameter
The matte is taken off in disks as it cools,
by means of iron hooks. Each casting pit
makes from 9-13 disks, weighing about 1500 lbs
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The following is an analysis of the matte; ——————

Copper	23.41
Iron	47.00
Sulphur	22.08
Alumina	0.40
Manganese	0.24
Lime	0.85
Magnesia	0.38
Silicious Residue	.57
Total	97.93

The slags flowing from the furnace are separated into poor and rich slags. The rich slags are put directly back into the furnace; the poor are sent to the dump heap.

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The analysis of the rich slag from both the ore and matte is as follows: —

Copper	1.35
Iron	40.83
Sulphur	2.87
Alumina	4.84
Manganese	1.17
Lime	9.87
Magnesia	1.12
SiO_2 Residue	25.96

Analysis of Poor Slag.

Copper	.57
Iron	40.83
Sulphur	1.82
Alumina	4.29
Manganese	1.11
Lime	9.59
Magnesia	1.11
SiO_2 Residue	27.56.

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The poor slags do not differ essentially in composition from the rich, except in the quantity of copper they contain. They are generally produced a little before and at the time of casting. The number of slag-pots for each ore furnace is seven. They are made of cast iron with lugs on the sides so that they can be easily taken up and tipped. The total number of slag-pots filled in the course of 12 hours is 90.

From the ore-furnace four of these pots contain rich slag.

The casting is made about once in eight hours.

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Roasting the Single Mattes

The Matte is broken up and roasted in piles which are made under three sheds.
The mattes are broken up into small fragments with hammers.
It takes about 5 days to burn one pile and the matte is roasted 6 times before it is ready for the furnace.
Each pile contains about 37 tons.
The number of piles required for the matte-furnace is seventeen.
One of these being taken down fully roasted; one is being built with raw matte; two are being turned and fired every day by 2 sets of men.
Thus there are 13 piles burning every day and 4 not burning.

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Analysis of Roasted Mattes.

Copper	18.26
Iron	39.82
Sulphur	3.38
Manganese	.28
Lime	1.10
Magnesia	trace
Silicious Residue	14.50
	77.34

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Iron	39.82
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Magnesia	Trace
Silicious Residue	14.50
	77.34

Fusion for Black Copper

The roasted mattes are now
fused for black copper and
concentrated or double mattes.
The furnace is exactly similar
to the ore furnace. In addition
to the roasted mattes, all the slags
from the refining furnace are
added to the charge in the furnace.
The charging bed is made of 3 loads
of matte weighing 1700 lbs., one load
of rich slag and 15 shovels of clay
to each load of ore.
The casting is done in pigs, which
weigh from 50 to 400 lbs. according
to their length. The quantity of
black copper produced in 24
hours is 3500 to 4000 lbs. averaging
85%.
The matte produced amounts to
3000 lbs. and average about 55%.
This matte forms a thin coating
on the top of the black copper and
is easily detached from it by the
blow of a hammer.
It is called a double or concentrated
matte or sometimes a thin
matte.

It contains considerable quantities of shot-copper, but no attempt is made to separate this.
The following is an analysis of

Black Copper

Copper	94.24
Iron	3.38
Sulphur	0.74
Lead	0.02
Lime	1.35
	99.73

Treatment of the Salamanders

All the loupes and salamanders which form in any of the furnaces are treated within the winter-time for the copper they contain. They are collected during the rest of the year and are deposited on the side of the slag heaps.
They contain a large amount of copper and were formerly a source of considerable loss, since all the attempts to treat them as part of the ordinary charge failed.
The treatment consists of oxidizing and then sweating them in a German hearth, made by taking out the breast of one of the black-copper furnaces.
The furnace is heated with charcoal and the salamanders piled up against the tuyere side and covered with charcoal and a powerful blast turned on.
This serves to oxidize the iron and in order to scorify it, a little quartz is added.
The product is a rich matte which

is treated with the other mattes
and a black copper, which is put
with the other black copper.
There is about four times as much
black copper as mattes.
The slags are very rich and
contain at least 1½ o/o of copper
and are treated with the matte
in the furnaces.
Three charges are put in the
furnace every 24 hours. and
about two tons of salamanders
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Refining the Pig Copper.

As there is not suppicient pig copper made for continuous running, the refining furnace is lighted only once a week.
When the furnace is brought to a white heat, the hearth is repaired by filling up any cavities that may have formed in it with sand, beating it down and making the sides and bottom with an even slope towards the sump, under the flue.
When this has been done the temperature of the furnace is lowered by opening all doors.
When it is reduced to a red-heat the pig-copper is charged through the charging door on the side & so distributed over the hearth that it will be easily reached by the heat.
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of oxidation at this stage, so that the foreign metals may at once combine with the silica.
The slags are not drawn until they cover the whole bath.
These slags are pasty and iron-rabbles are used to draw them off.
The operation of refining, after the metal is in fusion, consists of 3 distinct phases, firing, refining and ladling or casting, the first of which, firing, now commences.
The charge after being crassed, is subjected to a very strong oxidizing atmosphere in order to run the impurities into slag.
The charge is rabbled every 25 or 30 minutes for from 3 to 12 hours, until it boils from evolution of sulphur.
It is allowed to boil from one to 3 hours.
When it ceases to boil there is no more sulphur present and it is rabbled from 3 to 5 hours and crassed whenever necessary.
The crasses consist of a very friable material which contains a considerable amount of metallic copper in grains.

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When all the slags have been removed the atmosphere of the furnace is still kept oxidizing in order to remove any trace of impurity except a very small amount of silver & lead. The metal is rabbled and test-pieces are taken in order to ascertain its exact quality.

The operation of rabbling is continued for some time, in order to make sure that all impurities possible shall be separated as oxides, for which reason a considerable amount of Copper Oxide is formed.

When the operation of rabbling is finished, this oxide must be separated by a process of refining, for which purpose poling is resorted to.

The operation of Firing is one of Oxidation.

When the assay shows that the impurities are oxidized, the rabbling is discontinued, and refining, which is a reduction, takes place. A green or very wet pole is used for this purpose, and is put

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into the copper and held there.
All the air holes in the furnace
are there stopped up, and the
poling is continued until the slag
is thick, so it can be skimmed off.
This takes about 2 hours.

The Copper is then covered with
charcoal and a fresh pole is put in;
when samples are taken; the first
one half an hour from the time the
second poling began, and the others
during the poling, every 15 or 20
minutes, until the Copper is tough
pitch, which takes about one hour.
As soon as the tests show the
proper grain and silky lustre,
the metal is cast into ingot moulds
by means of iron ladles covered with
a wash of clay.

The ladling takes about two hours.
A man stands by and skims from
the surface of the copper any specks
that may be floating about which
would make any imperfection in
the ingot.
It is essential that the casting
should be done at the lowest
possible temperature and that the
bath be covered with charcoal.

About seven cords of wood are consumed every 24 hours.
The operation of ladling or casting is very difficult and can only be well done under the very best conditions.
The casting should be made by pouring quietly, so as to produce the least possible motion in the metal and this should continue until the last drop is out of the Ladle.

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Rolla, Mo. March 14th '87.

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